The NASA SCI Files™

The Case of the Technical Knockout

Segment 2

Still concerned that their Global Positioning System (GPS) receivers and radios might go on the blink again, Tony and Catherine go to NASA Langley Research Center to talk to Mr. George Ganoe to learn more about the GPS and how it works. After speaking with Mr. Ganoe, the detectives decide that it probably wasn't the GPS satellite system that caused the communications problem, but they begin to think that it might have something to do with radio waves. They decide to email two of the NASA SCI Files™ Kids' Club members in Norway, Ole and Nina, to talk with Dr. D. He meets Ole and Nina at the ALOMAR Observatory in Andenes, Norway where he explains the electromagnetic spectrum. Meanwhile, back in the U.S., Tony heads to Colorado and takes time to stop by the University of Colorado to visit Dr. Fran Bagenal to learn about electricity.

Objectives

Students will

- understand that the GPS depends on a system of 24 satellites.
- understand how the GPS works.
- recognize that the electromagnetic spectrum consists of many different forms of light.
- know that light has various wavelengths and frequencies.
- label the parts of an atom.
- understand attractive forces.
- know the difference between static and current electricity.

Vocabulary

atom—the smallest particle of an element that still has all the properties of that element

attract—to drive or bring together

battery—one or more cells that are connected and use chemicals to generate and store energy

current—moving electrical charges

electricity—a form of energy produced by the flow or accumulation of charges

electromagnetic spectrum—the classification of electromagnetic waves, either by wavelength or frequency

electromagnetic wave—a wave with electric and magnetic components

electron—one of three subatomic particles; has a negative charge

force—a push or pull; a force can be attractive or repulsive

frequency—number of complete waves (or cycles) that pass a fixed point in a given unit of time

magnetism—a phenomenon produced by moving charges

neutron—one of the two particles that make up the nucleus of an atom; it has no electric charge

nucleus—the positively charged central region of an atom, consisting of protons and neutrons and containing most of the mass

proton—one of the two particles that make up the nucleus of an atom; it has a positive electric charge

radio waves—electromagnetic waves having long wavelengths; used to transmit voice, music, video, and data over distances

repel—to drive or to force away

satellite—an object put into orbit around Earth or any other planet to relay communications signals or transmit scientific data

sphere—a round, three-dimensional object whose surface at all points is the same distance from its center

static electricity—the buildup of electrical charges on surfaces produced by rubbing two dissimilar materials against each other. In this type of electricity, the electrical charge is on something, and it does not move through a circuit.

three dimensional—possessing or appearing to possess the dimensions of length, width, and height

trilateration—mathematical principle that uses the intersection of three circles or spheres to locate a specific point in either two- or three-dimensional space

two-dimensional—used to describe a figure that has length and width but no depth

wave—a pattern that repeats itself in time and space

wavelength—the distance between a point on one wave and the identical point on the next wave; usually measured crest-to-crest or trough-to-trough

Video Component

Implementation Strategy

The NASA SCI Files™ is designed to enhance and enrich existing curriculum. Two to three days of class time are suggested for each segment to fully use video, resources, activities, and web site.

Before Viewing

1. Prior to viewing Segment 2 of *The Case of Technical Knockout*, discuss the previous segment to review the problem and reaffirm what the tree house detectives have learned thus far. Download a copy of the **Problem Board** from the NASA SCI Files™ web site, select **Educators**, and click on the **Tools** section. The **Problem Board** is also in the **Problem-Solving Tools** section of the latest online investigation. Have students use it to sort the information learned so far.
2. Review the list of questions and issues that the students created prior to viewing Segment 1 and determine which, if any, were answered in the video or in the students' own research.
3. Revise and correct any misconceptions that may have occurred during Segment 1. Use tools located on the Web, as was previously mentioned in Segment 1.
4. Review the list of ideas and additional questions that were created after viewing Segment 1.
5. Read the Overview for Segment 2 and have students add any questions to their lists that will help them better understand the problem.
6. **Focus Questions**—Print the questions from the web site ahead of time for students to copy into their science journals. Encourage students to take notes while viewing the program to help them answer the questions. An icon will appear when the answer is near.
7. **"What's Up?" Questions**—These questions at the end of the segment help students predict what actions the tree house detectives should take next in the investigation process and how the information learned will affect the case. They can be printed from the web site ahead of time for students to copy into their science journals.

View Segment 2 of the Video

For optimal educational benefit, view *The Case of Technical Knockout* in 15-minute segments and not in its entirety. If you are viewing a taped copy of the program, you may want to stop the video when the Focus Question icon appears to allow students time to answer the question.

After Viewing

1. Have students reflect on the "What's Up?" Questions asked at the end of the segment.
2. Discuss the Focus Questions.
3. Have students work in small groups or as a class to discuss and list what they now know about orienteering, using a compass, GPS, satellites, the electromagnetic spectrum, and electricity. As a class, reach a consensus on what additional information is needed.
4. Organize the information and determine whether any of the students' questions from the previous segments were answered.
5. Decide what additional information the tree house detectives need to determine what has caused the GPS and the radios to go on the blink. Have students conduct independent research or provide students with information as needed. Visit the NASA SCI Files™ web site for an additional list of resources for both students and educators.
6. Choose activities from the **Educator Guide** and web site to reinforce concepts discussed in the segment. Pinpoint areas in your curriculum that may need to be reinforced and use activities to aid student understanding in those areas.
7. For related activities from previous programs, download the **Educator Guide**. On the NASA SCI Files™ home page, select **Educators**. Click on **Episodes** in the menu bar at the top. Scroll down to the **2002–2003** Season and click on *The Case of the Shaky Quake*. In the green box, click on **Download the Educator Guide**.

a. In the **Educator Guide** you will find

   a. Segment 4 – *Locating an Epicenter* (triangulation/ trilateration)

   Close the PDF window and return to the page for **Guides**. Click on the **Archives** tab and then click on the **2000–2001** Season. To download the guide, click on **Full Guide** or the Segment indicated for *The Case of the Electrical Mystery*.

a. In the **Educator Guide** you will find

   a. Segment 1 – *Cling On* (static electricity), *Atoms & Atoms Everywhere* (parts of an atom)

   b. Segment 2 – *Battery Tester* (current electricity)

   c. Segment 3 – *Light the Bulb!* (current electricity)

   d. Segment 4 – *Word Search, Measuring Electricity 101, Electrifying Math*

   Close the PDF window and return to the page for **Guides**. Click on the **Archives** tab and then click on the **2001–2002** Season. To download the guide, click on **Full Guide** or the **Segment** indicated for *The Case of the Mysterious Red Light*.

a. In the **Educator Guide** you will find

a. Segment 1 – *Roping the Wave* (light travels in waves), *Wave Upon Wave* (frequency), *Roll Out the Frequency* (frequency and wavelength), *The Incredible Edible Wave* (parts of a wave)

b. Segment 3 – *Over the Rainbow* (visible spectrum), *Primary Colors of Light* (white light), *Rainbow of Knowledge* (visible spectrum)

8. If time did not permit you to begin the web activity at the conclusion of Segment 1, refer to number 6 under **After Viewing** on page 15 and begin the Problem-Based Learning activity on the NASA SCI Files™ web site. If the web activity was begun, monitor students as they research within their selected roles, review criteria as needed, and encourage the use of the following portions of the online, Problem-Based Learning activity:

   Research Rack—books, Internet sites, and research tools

   Problem-Solving Tools—tools and strategies to help guide the problem-solving process

   Dr. D's Lab—interactive activities and simulations

   Media Zone—interviews with experts from this segment

   Expert's Corner—listing of Ask-An-Expert sites and biographies of experts featured in the broadcast

9. Have students write in their journals what they have learned from this segment and from their own experimentation and research. If needed, give students specific questions to reflect upon as suggested on the **PBL Facilitator Prompting Questions** instructional tool found by selecting **Educators** on the web site.

10. Continue to assess the students' learning, as appropriate, by using their journal writings, problem logs, scientific investigation logs, and other tools that can be found on the web site. For more assessment ideas and tools, go to **Educators** and click on **Instructional Tools** in the menu bar.

Careers

computer programmer
electrical engineer
electronics engineer
electrician
physicist
radar technician
robotics engineer
satellite engineer/technician
spacecraft engineer

Resources *(additional resources located on web site)*

Books

Baler Wendy, Alexandra Parsons, and Andrew Haslam: *Electricity (Make it Work! Science)*. Two-Can Publishers, 2000, ISBN: 1587283549.

Barnes and Noble: *Satellite World Atlas*. Barnes and Noble Books, 2003, ISBN: 0760747474.

Cast, C. Vance and Sue Wilkinson: *Where Does Electricity Come From?* Barron's Educational Series, 1992, ISBN: 0812048350.

Cole, Joanna: *The Magic School Bus and the Electric Field Trip*. Scholastic, Inc., 1997, ISBN: 0590446827.

Gould, Alan and Stephen Pompea: *Invisible Universe: The Electromagnetic Spectrum from Radio Waves to Gamma Rays: Grades 6–8 (Gems Guides*). LHS GEMS, 2002, ISBN: 0924886692.

Levine, Shar and Leslie Johnstone: *Shocking Science: Fun and Fascinating Electrical Experiments*. Sterling Publishing Co., Inc., 1999. ISBN: 080693946X.

de Pinna, Simon: *Electricity*. Raintree Steck-Vaughn Publishers, 1998, ISBN: 0817249451.

Snedden, Robert: *Electricity and Magnetism*. Heinemann Library, 1999, ISBN: 1575728680.

Trumbauer, Lisa: *What Is Electricity? (Rookie Read-About Science)*. Children's Press, 2004, ISBN: 0516258451.

Van Cleave, Janice: *Janice Van Cleave's Electricity: Mind-Boggling Experiments You Can Turn Into Science Fair Projects*. John Wiley & Sons, Inc., 1994, ISBN: 0471310307.

Video

Disney: *Energy (Bill Nye, the Science Guy)*
Grades 3–8

Disney: *Light and Color (Bill Nye, the Science Guy)*
Grades 3–8

Schlessinger Media: *Forces (Physical Science in Action)*
Grades 5–8

Web Sites

NASA: Look to the Future—Careers in Space
Not every space career involves hopping around in a big space suit. Some are very "down-to-Earth." Explore this site to learn about lots of available opportunities for exciting space careers and read about the men and women who are working in them now. This site also offers some great tips on how to pursue your dream of a space career!
http://mgs-mager.gsfc.nasa.gov/Kids/careers.html

NASA Satellite Tracking
Do you know where the Hubble Space Telescope and other satellites are? Visit this site to find out as you track their paths across the Earth's surface.
http://liftoff.msfc.nasa.gov/academy/rocket_sci/satellites/

NASA: Visible Earth Images
Spend some time at this site looking through the hundreds of images taken by the many satellites orbiting our Earth.
http://visibleearth.nasa.gov/

Canadian Space Agency: Careers
Visit this site to learn about exciting careers in aerospace and more.
http://www.space.gc.ca/asc/eng/educators/careers_engineers.asp

HowStuffWorks: Trilateration Basics
This site offers a great explanation, graphics, and animations of trilateration in both two- and three-dimensional space.
http://electronics.howstuffworks.com/gps1.htm

Global Positioning System Overview
An in-depth look at how a GPS works by Peter H. Dana. The University of Texas developed the content for this site (posted by the University of Colorado at Boulder).
http://www.colorado.edu/geography/gcraft/notes/gps/gps_f.html

GPS Constellation
At this site, view a graphic representation of the constellation of satellites that orbit the Earth for the GPS.
http://www.colorado.edu/geography/gcraft/notes/gps/gps_f.html

Artic Lidar Observatory for Middle Atmosphere Research (ALOMAR)
Learn how the observatory studies the middle atmosphere to learn more about auroras and clouds.
http://alomar.rocketrange.no/rmr.html

PBS Online: Radio Transmission
This PBS web site shares a wealth of information about radio waves. Check out an interactive explanation of radio transmission.
http://www.pbs.org/wgbh/aso/tryit/radio/#

The Electromagnetic Spectrum
Visit this NASA web site to learn about electromagnetic waves. Get detailed descriptions of each type of electromagnetic wave.
http://imagers.gsfc.nasa.gov/ems/radio.html

Waves and Wave-Like Motion
Visit this web site to learn about the nature, properties, and behavior of waves.
http://www.glenbrook.k12.il.us/gbssci/phys/Class/waves/u10l1a.html

Tucson Electric Power Company's "Sunsite Funsite"
Experience an introduction to solar energy on this interactive web site.
http://www.eeexchange.org/solar/frameset.htm

Power Discovery Zone
Discover electricity, learn about the atom, play games, get some great lesson plans and more on this site.
http://www.powerdiscoveryzone.com/home.html

Home's Cool: Electricity A to Z
This wonderful site has great modules on everything from A to Z in electricity. Watch animated modules and use easy-to-read texts. Find some easy and fun-filled experiments to do at home.
http://homeschooling.gomilpitas.com/explore/electricity.htm

Solar Matters
The Florida Solar Energy Center's web site offers numerous facts about solar energy.
http://www.fsec.ucf.edu/ed/sm/ch1-general/whatis.htm

NASA's Kids Science News Network™ (KSNN™)
Visit KSNN™ to learn more about trilateration. Watch the one-minute news clip, "How do you tell time in space?" There are also additional activities and resources available.
http://ksnn.larc.nasa.gov

Activities and Worksheets

It Takes Four

Segment 2

Purpose

To use topographic maps to determine the elevation of a specific location

Teacher Prep

Using a clear plastic storage container with a clear lid and clay, form a hill in the middle of the box(es). Be sure that the hill is not larger than the height of the box.

Materials

clear plastic landform box
water
beaker
transparency
metric ruler
tape
transparency marker
white paper

Background

Elevation is the distance above or below sea level, and it is useful to know the elevation of an area for many reasons. For example, elevation can affect the cooking times of many recipes, as well as your ability to run long distances or even hike. If you are out hiking and have at least four satellites linked to your GPS device, you might be able to determine the elevation of the area. However, many hikers also depend on topographic maps to give them accurate elevation information. A topographic map shows the changes in the elevation of Earth's surface. With a topographic map, you can tell how steep the mountain trail is. It also shows natural features such as mountains, hills, plains, lakes, rivers, and cultural features such as roads, cities, dams, and other man-made structures. Before starting a hiking trip, you could look at the contour lines on the topographic map to see what elevation changes the trail has. A contour line on a map connects points of equal elevation, and they never cross. The contour interval is the difference in elevation between two side-by-side contour lines. By looking at the contour interval to see how close the contour lines are to each other, you can determine whether a trail is steep or if it is gently sloping. Knowing the elevation can prepare you for your hike. The ancient Chinese were the first people to develop physical relief maps. These maps, produced sometime in the 3rd century BC, showed changes in elevation and were often carved from wood or made from molded rice.

Procedure

1. Using the ruler and the transparency marker, make marks up one side of the clear box 2 cm apart. The bottom of the box will be zero elevation. See diagram 1.
2. Use tape to secure the transparency to the top of the clear box lid.
3. Using the beaker, pour water into the box to a height of 2 cm.
4. Place the lid back on the box and observe.
5. Use the transparency marker to trace the top of the water line on the transparency.
6. Using the scale 2 cm = 10 m, mark the elevation on the contour line.
7. Remove the lid and add water until it is 4 cm deep.
8. Repeat steps 4–6.
9. Continue adding water and repeating the process until the hill is mapped.
10. Remove the transparency from the lid and place it under a piece of plain, white paper.
11. Carefully trace the lines from the transparency onto the white paper and label the contour intervals.

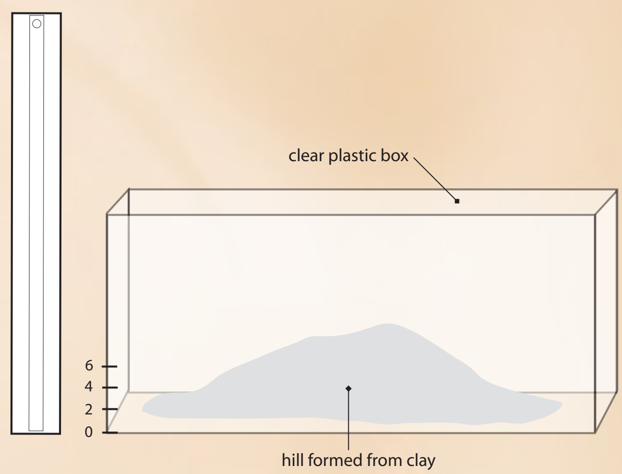


Diagram 1

It Takes Four

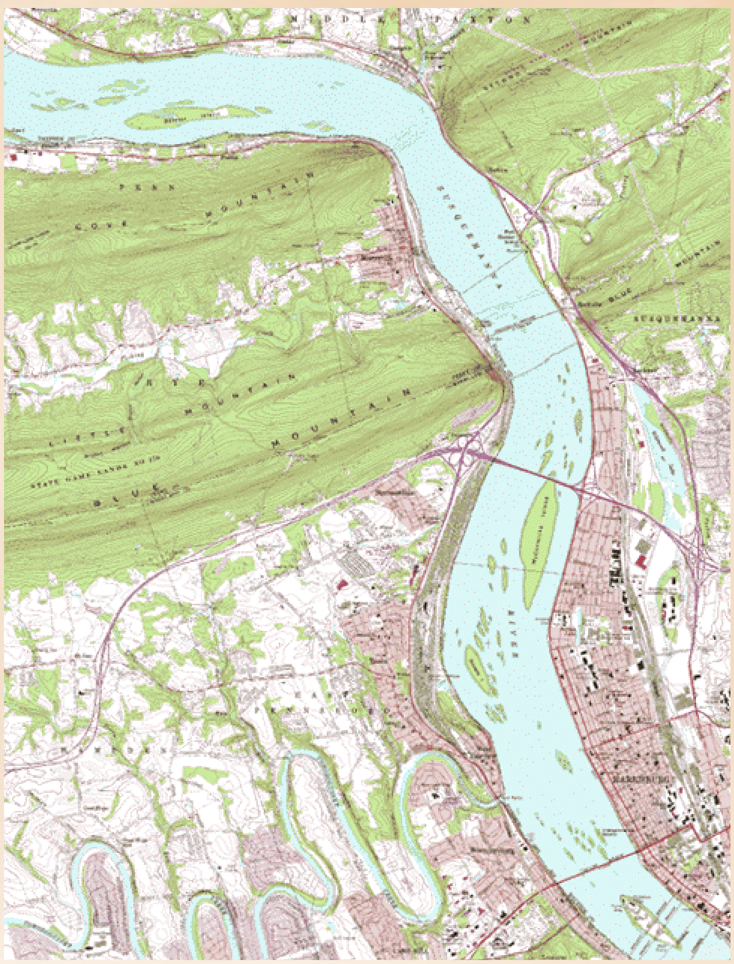
Segment 2

Conclusion

1. What is the contour interval of this topographic map? What is the total elevation of the hill?
2. How does the distance between the contour lines show the steepness of the slope on this model of a hill?
3. Do all topographic maps have a 0-m elevation contour line? Explain.
4. On a topographic map, how would the contour interval of an area that has hills compare to one that is very flat.
5. GPS devices can be used to show elevation and location. Why would it be a good idea to also carry a topographic map when hiking? What other supplies would you want to have?

Extensions

1. Visit the United States Geological Survey (USGS) site to learn more about topographic maps. http://geography.usgs.gov/digitalbackyard/topobkyd.html
2. Visit Topozone to find a free, topographic map of your area. http://www.topozone.com/
3. Visit USGS's TerraWeb for Kids to check out satellite images and to learn how computers use the images to make 3-D models of the Earth's surface. http://terraweb.wr.usgs.gov/TRS/kids/



Transversing the Wave

Segment 2

Purpose

To understand the relationship between wavelength and frequency

Materials

Per Group of 4
2-m rope
science journal

Background

Waves are all around us. You can see some of them, such as water and light waves. Others, like sound and radio waves, you cannot see. A wave is a repeating disturbance or movement that transfers energy through matter or space. For example, ocean waves disturb the water, earthquakes create waves that disturb the earth, and light is a type of wave that can travel through empty space. They all transfer energy from one place to another. Think about the last time you threw a pebble in a pool of water and watched how ripples formed. The pebble caused a disturbance that moved outward in the form of a wave and because it was moving, it had energy. As it splashed into the water, the pebble transferred some of its energy to nearby water molecules, causing them to move. Those molecules then passed the energy along to neighboring water molecules and so on until the energy moved farther and farther away from the disturbance.

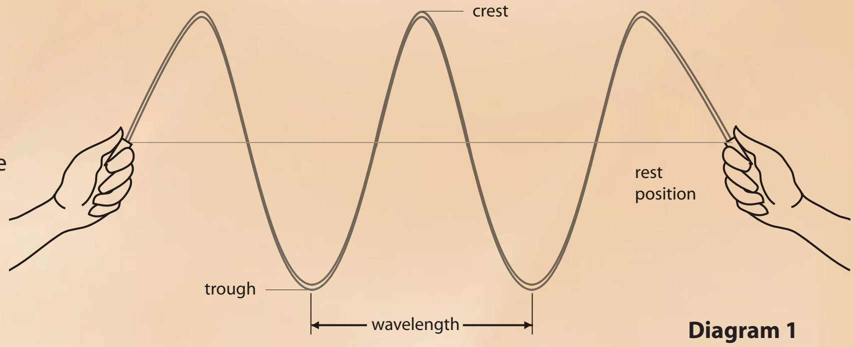


Diagram 1

Waves also have a property called wavelength, which is the distance between one point on a wave and the nearest point just like it. For example, in a transverse wave, there are alternating high and low points. The highest points are called the crests, and the lowest points are called the troughs. To measure wavelength, you would measure either crest to crest or trough to trough, as shown in Diagram 1.

Frequency is the number of wavelengths that pass a fixed point each second. You could find the frequency of a transverse wave by counting the number of crests or troughs that pass by a point each second. Frequency is expressed in hertz (Hz). A frequency of 1 Hz means that one wavelength passes by in one second.

If you move a rope up and down to make a transverse wave, you can increase the frequency by moving the rope up and down faster so more waves pass by a given point in one second. By moving the rope faster, you also shorten the wavelength.

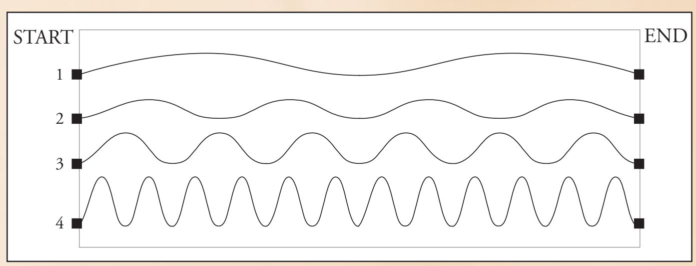


Diagram 2

Teacher Prep

In a large, open area, use ropes and/or cones to mark four waves with the same distance between end points but with different wavelengths. For example, draw one wave with only two crests in a 20-m distance. Draw a second wave with three or four crests for the same distance, and so on, increasing the number of crests with each wave. Mark the beginning of each wave and number all of them, starting with the longest wavelength as number 1. See diagram 2. NOTE: If you use ropes to mark off the waves, the various lengths of the four ropes will be determined by whatever distance between end points you choose.

Transversing the Wave

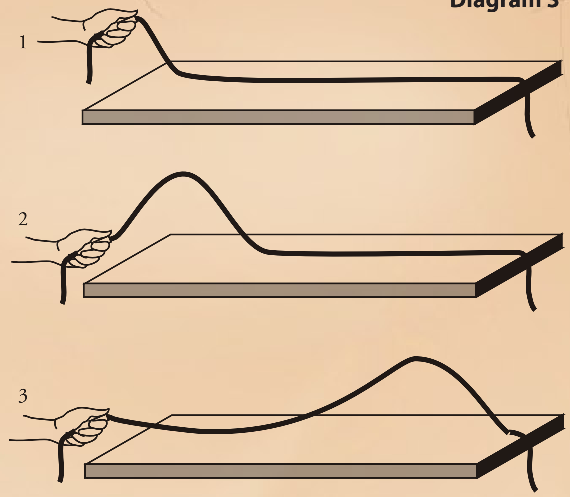
Segment 2

Procedure

Part 1

1. Hold one end of the rope and move your hand to make the rope move up and down. See diagram 3.
2. Observe and record your observations in your science journal.
3. Move your hand faster and observe. Watch what happens when you stop moving your hand. Record your observations.
4. In your science journal, explain what gives the rope the energy to move up and down.

Diagram 3



Part 2

5. Have each person in your group stand at the beginning of one of the four waves.
6. The person on wave number 1 will walk at a normal pace while the other three will need to change their paces so that they will finish at exactly the same time as the person on wave number 1.
7. Start walking when you're selected.
8. Once you have finished, record in your science journal any personal physical observations such as sweating, being out of breath, and so on.
9. In your science journal, describe how students on wave numbers 2–4 had to adjust their walking speed to finish at the same time as wave number 1 students.

Conclusions

1. What happened to the speed of the rope when you moved your hand faster?
2. What happened to the wavelength as the rope moved faster?
3. What happened to the number of crests and troughs as the rope moved faster?
4. When you walked the waves, what happened as the wavelengths got shorter?
5. If these were real waves passing a fixed point, which wave would have more crests and troughs to pass in the same amount of time? Explain.
6. Did you notice any physical changes as the wavelengths got shorter?
7. In your own words, describe the relationship between wavelength and frequency.

Extension

1. Using the colors of the electromagnetic spectrum, create different color signs to carry while walking the waves (red for the longest wavelength and violet for the shortest wavelength, and so on).
2. Research the various types of waves: transverse, longitudinal (compressional), sound, water, and seismic. Create a Venn diagram that shows the similarities and differences among the various waves.

Charge!

Segment 2

Purpose

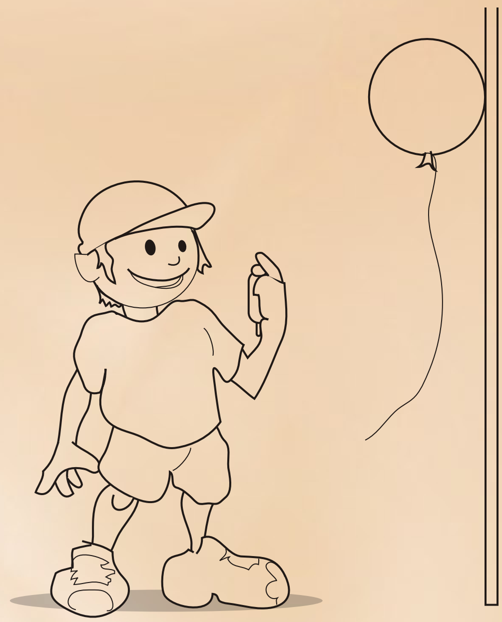
To understand that a static electrical charge is an increased concentration of an electrical charge in one place

Materials

balloon
stopwatch or clock with second hand
calculator (optional)

Background

All matter, including all living things, is made of very tiny pieces called atoms. An atom is the smallest piece of an element that can still be identified as that element. Atoms are made of even smaller pieces called protons (positive or +), neutrons (neutral), and electrons (negative or –). Atoms usually have the same number of protons and electrons. The amount of positive and negative charge is the same. In some materials, electrons are easily pulled off their atoms, which allows the electrons to move to another material. When the electrons are pulled from a material, it then has a more positive electrical charge. The material to which the electrons moved now has a more negative electrical charge. The two materials have opposite charges. Opposite charges attract while similar charges repel. When an electrical charge is connected to something and is not moving, we call it static electricity. You may have experienced static electricity when you've seen clothes stick together after coming out of the dryer. It is called static cling because it is caused by static electricity!



Procedure

1. Blow up one balloon and tie it closed.
2. Rub the balloon against your hair or clothes for 30 seconds and stick it on a wall.
3. Begin timing how long the balloon stays on the wall.
4. In the chart, record the time in seconds.
5. Repeat steps 2–4 for two more trials.
6. Repeat steps 2–5 for different intervals of time: 60 seconds, 90 seconds, and 120 seconds.
7. Calculate and record the average number of seconds the balloon stayed on the wall for each time interval. Note: To calculate the average, find the sum of all three times for each time interval and divide by three.
8. In the graph provided, create a bar graph of the results (average times).
9. Rub the balloon for 60 seconds, but this time have your partner rub his/her hands all over the balloon.
10. Stick it to a wall.
11. Observe. Record what happened and explain your observations.

Conclusions

1. What made the balloon stick to the wall?
2. Why did the balloon eventually fall off the wall?
3. Did the length of time you rubbed the balloon make a difference in the length of time the balloon stayed stuck to the wall? Explain why or why not.
4. What changed when you rubbed the balloon with your hands?
5. In your own words, explain static electricity.

Charge!

Segment 2

6. Why did the tree house detectives need to learn about electricity?

Trial	30 Seconds	60 Seconds	90 Seconds	120 Seconds
1				
2				
3				
Average Time				

Extension

1. Measure and cut 1.5 m of string. On one end of the string, tie a loop large enough to fit your hand through. Use helium to blow up two balloons. Tie each balloon closed and attach the end of the string without a loop to the balloon. Sit facing your partner and hold your balloons securely. Rub one of the balloons on your hair and then float both balloons above your heads. Move the balloons close together and observe. Rub both balloons on your hair and repeat the experiment. Explain what happened and why.
2. Tear a piece of paper into tiny pieces. Use the balloon to pick up the pieces of paper. Explain how this experiment works.
3. Rub a balloon on your hair for 60 seconds and then move the balloon slowly towards a tiny stream of running water. Observe what happens and explain.

The Current Detective

Segment 2

Purpose

To make a device to detect electric current

Background

Electrical current flowing in a coil of wire creates a magnet. Moving a magnet in a coil of wire creates an electrical current. The kind of current you use in your home is called alternating current—AC for short. It's called AC because the flow of the current changes direction.

Materials

compass
bar magnet
D-cell battery
D-cell holder
cardboard tube
3-m insulated wire with ends stripped (18 to 24 gauge)
1-m insulated wire with ends stripped (18 to 24 gauge)
transparent tape
science journal

Procedure

1. To make a current detector, use the 1-m wire and wrap 6 to 8 loops around the middle of the compass, going from north to south and leaving about 20 cm of extra wire on each end. See diagram 1.

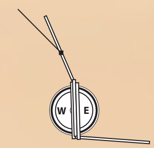
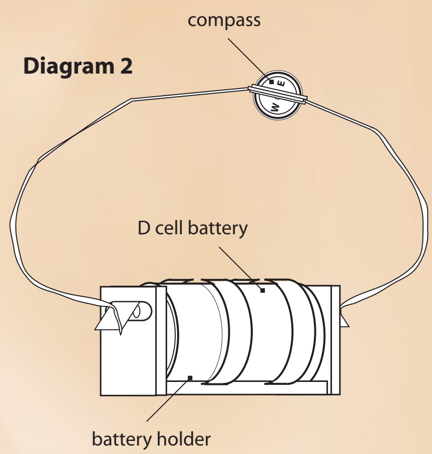


Diagram 1

2. Place the D-cell battery in the holder.
3. Line up the compass on your desk so that the needle points north and lines up with the wire loops.
4. Connect one end of the wire to the D-cell.
5. Briefly touch the end of the wire to the other end of the D-cell. See diagram 2.
6. Observe and record your observations in your science journal.
7. Wrap the 3-m wire around the cardboard tube. Make the loops as close together as possible but be sure not to overlap any loops. Leave 50 cm of wire at each end. See diagram 3.
8. Connect one wire on the current detector to one wire on the cardboard tube.
9. Repeat with the other two ends of wire. NOTE: You can use an empty D-cell battery holder to hold the wires together. See diagram 4.
10. Position the tube as far away as possible from the current detector.
11. Insert the bar magnet into the cardboard tube while your partner observes the compass.
12. Switch positions and record your observations in your science journal.
13. Predict what will happen when you reverse the position of the bar magnet.
14. Test your prediction and explain.

Diagram 2



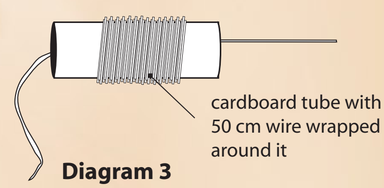


Diagram 3

Conclusions

1. Describe what happened to the compass when current ran through the wire.
2. Describe what happened when you reversed the position of the bar magnet in the tube.
3. In what way is the compass needle's movement evidence of a current in the wire?
4. What do you think produced a current in the wire?

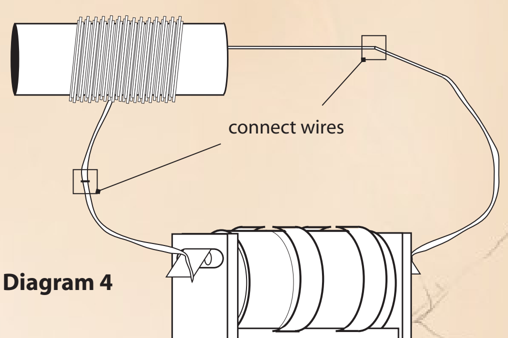


Diagram 4

Answer Key

Segment 2

It Takes 4

1. The contour interval is 10 m. The total elevation will vary but will always equal the height of the model in centimeters times 1000.
2. The closer together the contour lines are on the map, the steeper the slopes on the model. Increased distances between contour lines indicate relatively flat areas of the model.
3. No, the 0-m contour line is only on maps that have an elevation at sea level.
4. Generally, the greater the relief of an area, the larger the contour interval. Relatively flat areas of low relief are represented by smaller contour intervals.
5. Answers will vary but should include that GPS devices can sometimes stop working for various reasons, such as a dead battery. Therefore, a topographic map would be useful if GPS weren't available. Answers will vary and might include a compass—just in case the GPS has problems.

Transversing the Wave

1. As your hand moved faster, the speed of the rope increased.
2. The wavelength became shorter as the rope moved faster.
3. The number of crests and troughs increased as the rope moved faster. Frequency.
4. As the wavelengths got shorter, students had to walk faster to reach the end at the same time as the first wave.
5. The shortest wavelength would have more crests and troughs pass a fixed point. Because the wavelength is shorter, there are more of them in the same linear distance.
6. Answers will vary, but should include that as wavelength decreases, frequency increases.
7. They are inversely proportional.

Charge!

1. A neutral wall contains countless positive and negative charges. As a negatively charged balloon approaches the wall, the positive charges on the wall move toward the balloon and the negative charges move away from it. Because negative and positive charges attract each other, the balloon sticks to the wall. The wall becomes polarized and continues to attract the balloon and hold it in place until other forces act upon it.
2. Due to water vapor (humidity) being in the air, the excess charge leaks off into the atmosphere and the balloon goes back to a neutral charge. Once the balloon is neutral, it is not "attracted" to the wall and falls.
3. Answers will vary, but generally, the longer you rub the balloon, the longer it will stay on the wall. When you rub the balloon for a longer period of time, you increase the amount of charge on the balloon.
4. When you rubbed the balloon with your hands, the extra charge moved to your body, spread out, and traveled to the ground. Getting rid of extra electric charge by safely transferring it to the ground is called grounding the charge. Grounding is the easiest way to get rid of static electricity.
5. Answers will vary, but should include that static electricity is a buildup (excess) of nonmoving electric charge in one place that is caused by an excess or a lack of electrons.
6. Answers will vary but should include that the tree house detectives had problems with their two-way radios, and they know that an electrical charge can create radio waves. Therefore, they conclude that they should learn more about electricity.

The Current Detective

1. The compass moved when current ran through the wire.
2. The compass needle swings one way when the magnet is inserted and it swings the other way when it is pulled out. When you reverse the magnet, you cause the compass needle to swing in the opposite direction from how it originally swung.
3. When you moved the bar magnet into the coil of wire (tube), it induced a weak electric current in the coil. A compass is sensitive to electric current. When a compass detects an electric current, it moves.
4. The movement of the magnet through the coil produces the current. Faraday observed that whenever a coil is in the presence of a changing magnetic field, it causes a current in the coil.

On the Web

Groovin' On the AM Waves

1. When the bare wire moved against the fork, it generated electromagnetic radiation by releasing electric energy from the battery.
2. Answers will vary but should indicate that as the distance increased, the corresponding static was less.